

Prototype Flaking Head Smooths Surfaces Left by Headrig Or Edger Chipping Heads

Peter Koch

Abstract

Flaking heads arranged to follow headrig and edger chipper heads would smooth machined surfaces and produce high-value flakes of near optimum dimensions for structural flakeboard. In the proposed concept, eight knives are closely grouped in a 45-degree helix on a cutterhead tipped at 45-degree angle to the direction of workpiece feed. Each knife is set out in cutting radius the thickness of one flake (about 0.015 inch) from the immediately preceding knife. Thus an eight-knife head would, in each revolution, remove eight flakes 0.015 inch thick and perhaps 1 inch in length while making a cut about 1/8 inch deep, thereby removing traces of torn grain caused by chipper knives.

HEADRIG AND EDGER chippers cutting in the 90-0 and 90-90 modes are in widespread use in softwood mills throughout North America (Koch 1972, p. 836) and to a lesser extent throughout the rest of the world. They have been adopted because of their productivity per man-hour and because they make no sawdust. The chippers are not without disadvantages, however.

The Problem

Because their peripheral-milling and end-milling cutterheads take large bites per tooth to make pulp chips 5/8 to 7/8 inch in length, they tear out grain around knots and tend to splinter board edges. Resultant surfaces display torn grain extending perhaps 1/8 inch into board face or edge (Fig. 1).

These rough surfaces can be smoothed by planers adjusted to remove about 1/8 inch from board faces and edges. Because of the low value of planer shavings relative to lumber, however, mill operators are reluctant to take this remedial action.

Therefore, the next generation of chipping headrigs and edgers should be equipped with cutterheads that leave smooth surfaces. Mills equipped with such cutterheads acting in concert with multiple bandsaws could produce quality lumber with minimum labor input and minimum output of low-value sawdust and shavings.

A Solution

During the past two decades, pulp chips from sawmill residue have become very valuable. Now,

because the forest products industry is about to manufacture and market a major new commodity, structural flakeboard, another kind of high-value residue—flakes—is entering the picture. These flakes, which should have a value equal to or exceeding that of pulp chips, resemble tiny pieces of veneer and measure 0.015 to 0.025 inch thick and 1 to 3 inches long. Production of such flakes offers a solution to the problem of excessive torn grain.

The concept proposed is simple (Fig. 2). Immediately following each headrig (or edger) chipping cutterhead would be a smoothing head, located as suggested by Koch (1964, Fig. 7). This flaking head, designed to leave smooth surfaces, would be arranged to cut veneer-like particles in the manner of a veneer slicer (Fig. 3). Its mounting separate from the chipping head (Fig. 2) would permit easy separation and collection of both pulp chips and flakes and would allow ready adjustment of depth of cut of the flaking head, thus insuring a smooth finish free of the torn grain caused by the chipping head.

Evolution of Cutterhead Prototype

Substantial research in the manufacture of structural flakeboard (e.g., Hse, et al., 1975) has shown that flakes for such board must be cut in the veneer-slicing direction with good control of length (range 1 to 3 in.) and thickness (0.015 to 0.025 in.). If cut with knife edge parallel to the grain (Fig. 3), flake quality is excellent, and resultant surfaces are smooth and free of tearout.

Trial on Metal-Cutting Planer

In November 1974, a metal-working planer was arranged to cut blocks of green Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) as shown in Figure 3. Surface achieved was excellent as was flake quality (Fig. 4). There was no tearout at the edge where the knife left the cut.

The author is Chief Wood Scientist, So. Forest Expt. Sta., USDA Forest Service, Pineville, La. The cooperation of Stetson-Ross Machine Company, Seattle, Wash., in assisting with fabrication of the first prototype and in helping evaluate both prototype cutterheads, is acknowledged with appreciation. This paper was presented at Session 13—Milling & Machining—of the 29th Annual Meeting of the Forest Products Research Society, June 17, 1975, in Portland, Oreg. It was received for publication in April 1976.

Figure 1. — Extreme torn grain in southern pine processed through end-milling headrig and edger chippers. (Left) Torn grain around knot on board face. (Right) Torn grain on board edge.

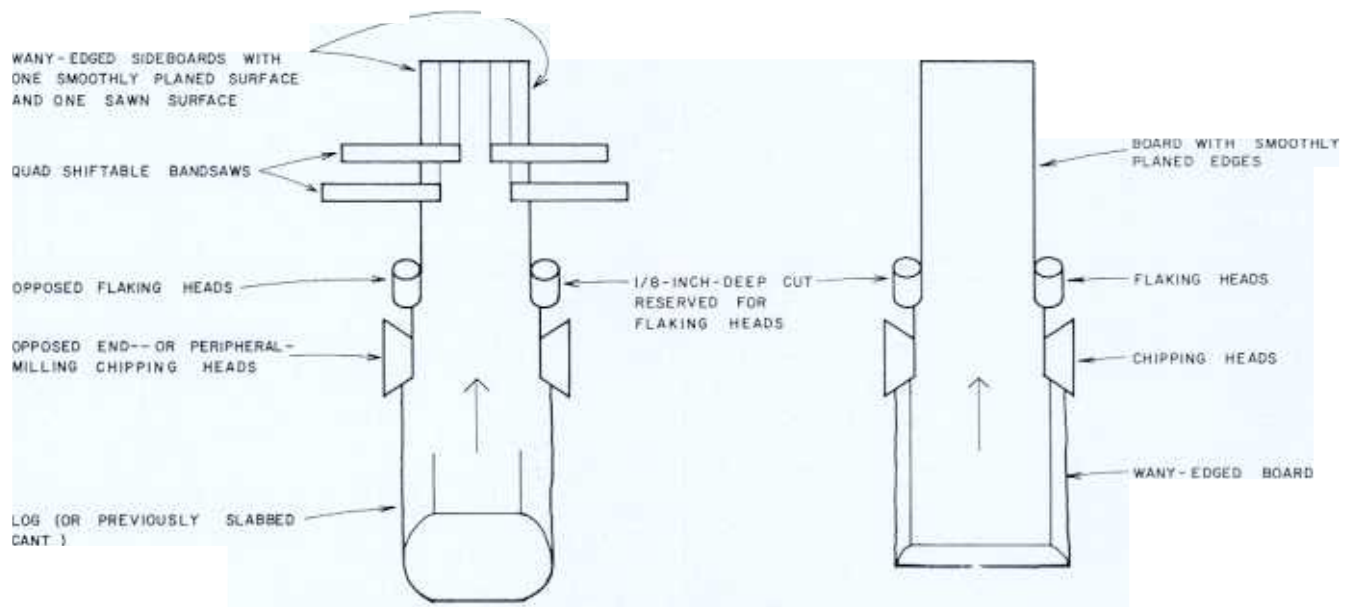
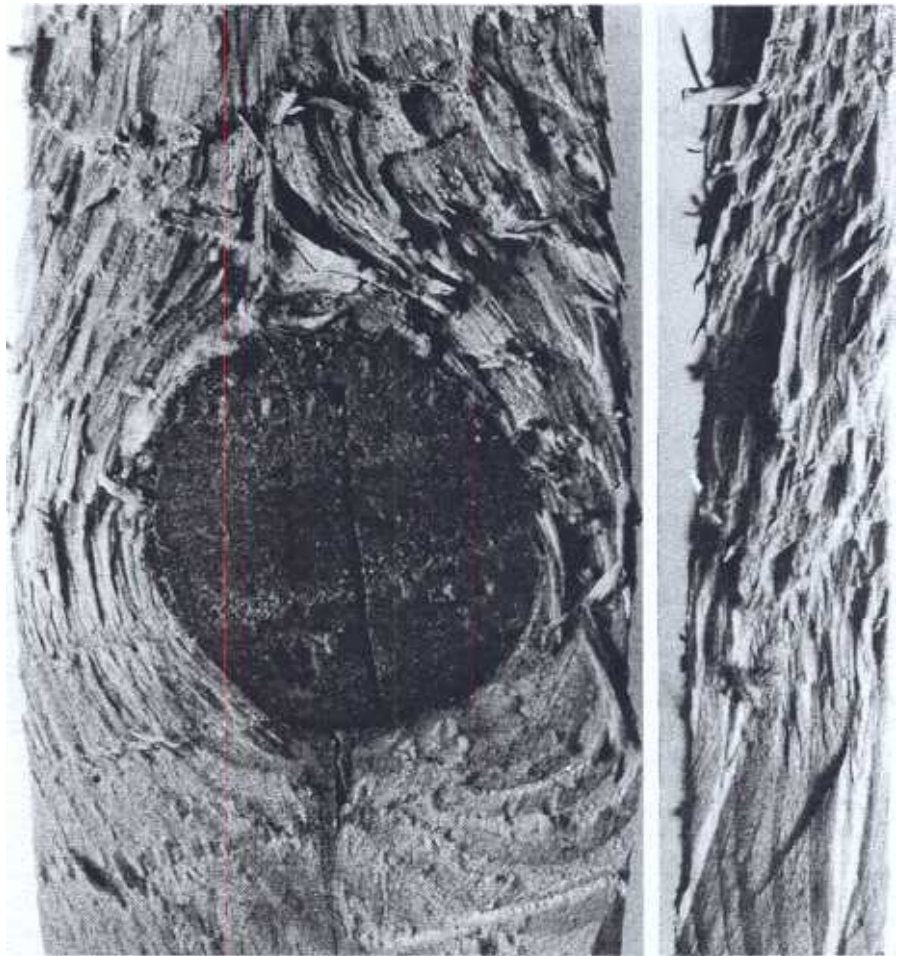


Figure 2. — Concept of flaking heads following chipping heads on headrig (left) and edger (right).

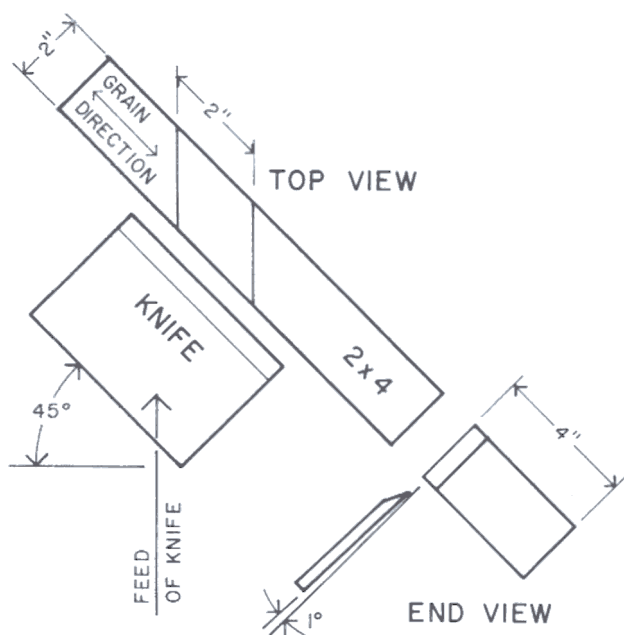


Figure 3. — Geometry of knife movement to cut veneer-like flakes from log face or board edge (see also Fig. 4).

Microtome Trials

To further explore effects of cutting geometry, a heavy sliding microtome was employed. The geometry shown in Figure 5 (left) yielded flakes, surfaces, and corners superior to those from the arrangement shown in Figure 3, which in turn gave better results than the arrangement of Figure 5 (right).

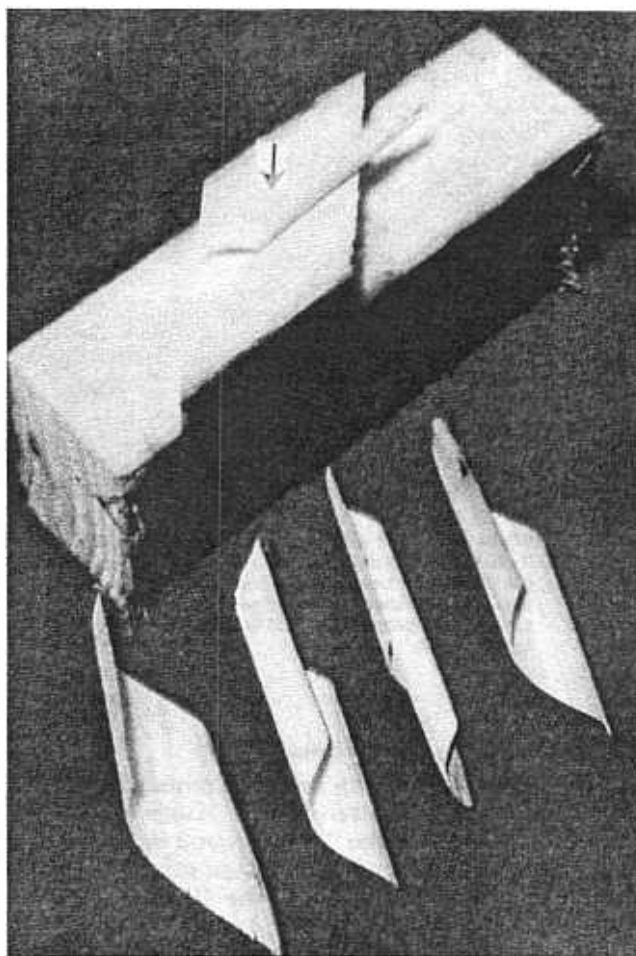


Figure 4. — Flakes 0.02 inch thick and resultant surface on green Douglas-fir cut in mode of Figure 3. Arrow indicates direction of knife travel.

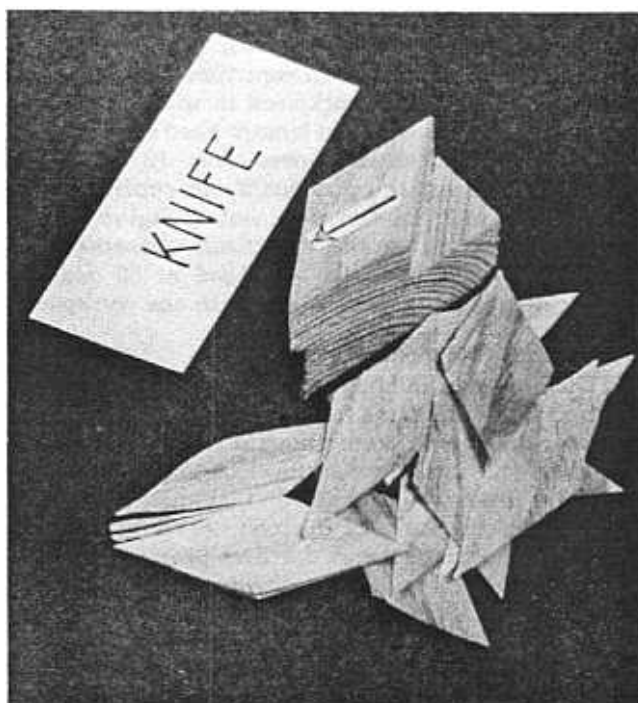
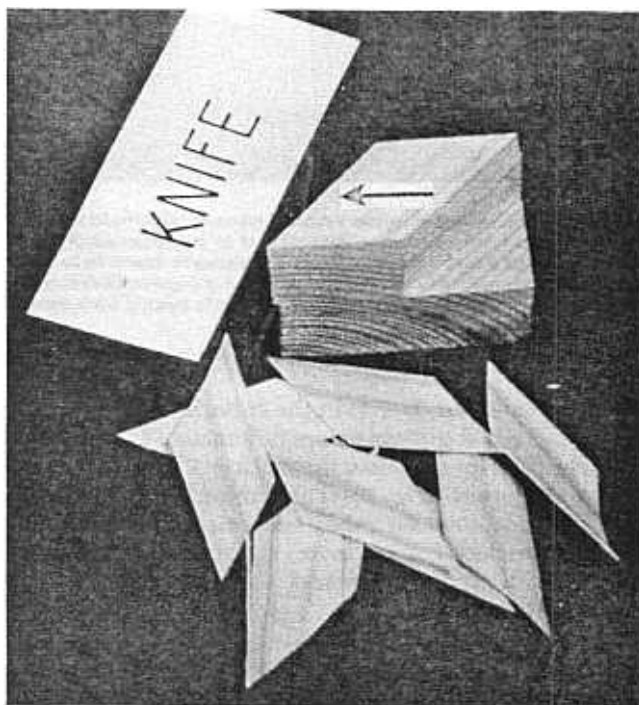


Figure 5. — Arrangement of microtome knife and resultant flakes. (Left) Best arrangement. (Right) Poorest arrangement. Arrows indicate direction of feed.

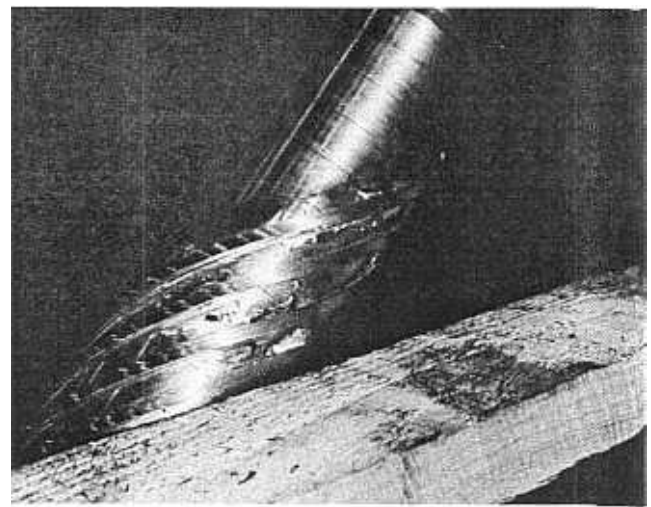
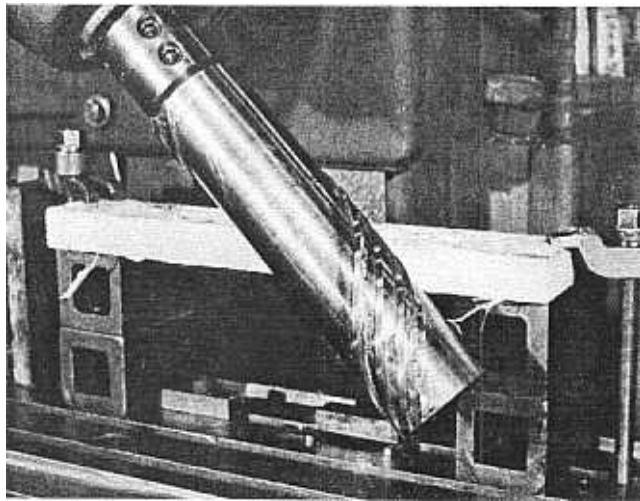


Figure 6. — First prototype of four-knife cutterhead cutting flakes 0.015 inch thick and 1 inch long from green Douglas-fir. Knife helix is 45 degrees, and cutterhead is tipped 45 degrees. (Left) In back view knives appear vertical; wood to the right of the cutterhead has been surfaced while that to the left is yet to be surfaced. (Right) In front view, all four knife edges are essentially parallel to grain of workpiece as they move to yield four veneer-like flakes with each revolution of the cutterhead. Lowest knife projects to 2.500 inch cutting radius, the next lowest to 2.515 inch, the third lowest to 2.530 inch, and the top knife to 2.545 inch.

First Prototype Cutterhead

To achieve the cutting action diagramed in Figure 3 with a rotating cutterhead, a single knife was wrapped in a 45-degree helix around a cutterhead tipped at 45 degrees to feed direction of a 2- by 4-inch Douglas-fir billet clamped on the bed of a milling machine. Behind this single knife were wrapped three additional knives, each sweeping a cutting radius 0.015 inch greater than the preceding knife (Fig. 6). Thus as each knife engaged the wood, it cut with edge essentially parallel to the grain (like a veneer slicer), yielding a flake 0.015 inch thick. Total depth of cut was 0.060 inch; i.e., 4 by 0.015 inch. As the cluster of four knives left the cut, sufficient time elapsed before re-engagement for the workpiece to move forward 1 inch to yield flakes 1 inch in length. Feed speed was 12 in./min., and cutterhead speed was 12 rpm. The experiment showed the practicality of cutting in the mode of Figure 3. The arrangement of Figure 5 (left), while preferable, seemed difficult because the cutterhead would have to be tipped at 60 degrees, thereby approaching parallelism with the workpiece.

Second Prototype Cutterhead

The knives in the first prototype were of mild steel and had zero rake angle (angle between knife face and a plane passing through the knife tip and perpendicular to the workpiece surface). Although this first prototype illustrated the concept, it made less than perfect flakes because of the zero-degree rake angle. Moreover, the diameter of the first prototype was so small (about 5 in.) and knife curvature so extreme that individual knife traces were quite prominent.

A second four-knife prototype was therefore assembled in which the cutting circle diameter was slightly more than 12 inches and rake angle was about 60 degrees. The removable knives were high-speed steel and were warped slightly to assure the necessary

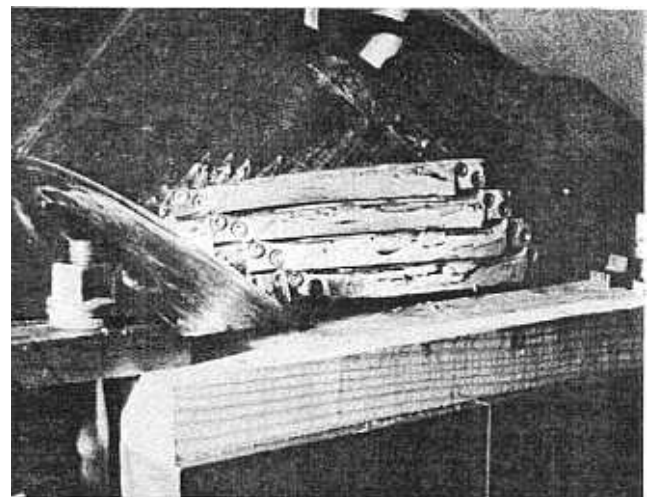


Figure 7. — Twelve-inch-diameter second prototype cutterhead with four knives arranged in a 45-degree helix poised to cut (downwardly) four 0.015-inch-thick flakes from the edge of a Douglas-fir board. Rake angle is about 60 degrees and clearance angle about 5 degrees (measured in plane perpendicular to cutting edge). The board is moving from right to left.

helical shape (Fig. 7). Again the cutterhead was turned at 12 rpm while the workpiece advanced at 12 in./min. to yield 0.015-inch flakes measuring 1 inch in length along the grain (Fig. 8). The throat between knives proved inadequate for ready escape of the flakes, and it was concluded that more gullet space would be needed in a production model.

This second prototype left a surface somewhat comparable to that left by a high-speed planer and matcher (Fig. 9 left); incident lighting clearly revealed individual knife traces (Fig. 9 right). The lower edge of the workpiece splintered slightly, but it seemed better than a bandsawed edge.



Figure 8. — Flakes from the cutterhead shown in Figure 7. They measured 0.015-inch-thick and 1 inch in length along the grain. Ends were slightly tapered.

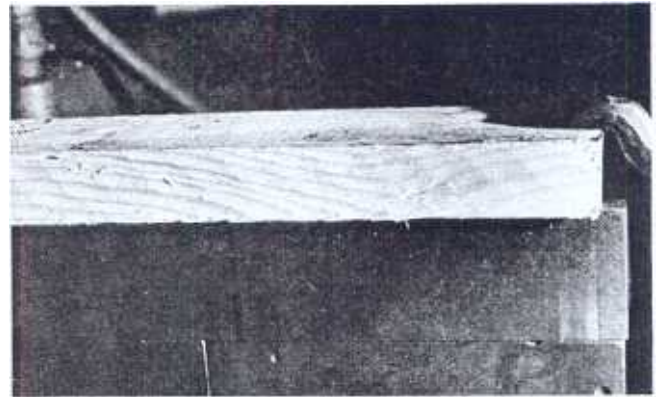
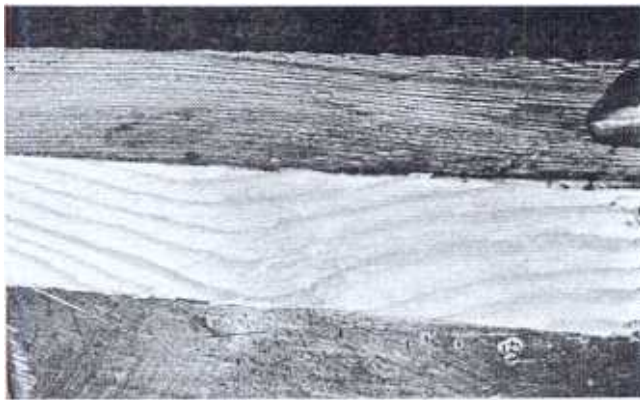


Figure 9. — Surfaces of green Douglas-fir machined with cutterhead shown in Figure 7. (Left) Brightly lighted machined edge compares favorably with conventionally planed top surface. (Right) Incident lighting shows traces of the single knife with largest cutting-circle diameter; i.e., the top knife of Figure 7.

Discussion

Based on experience with the prototype cutterheads, it seems desirable to seek a practical cutterhead design to exploit this concept. The commercial prototype should carry eight knives, each set at a different cutting-circle diameter so that each would cut one 0.015-inch-thick flake per revolution of the head. An eight-knife design would permit a smoothing cut of 1/8 inch depth (i.e., 8 by 0.015 in.). If such a cutterhead rotated at 1,800 rpm and workpiece feed speed was 150 fpm, then flake length would be 1 inch (i.e., 150 by 12/1,800). For headrig use, the cutterhead should have a nominal cutting circle of 18 inches and knives long enough to surface a 16-inch face. For most edgers, only a 4-inch surface need be machined.

Simpler cutterhead designs have been tested by others. For example, the helical cutterheads for flake cutting tried by Stewart (1971) and by Stewart and Lehmann (1974) are less complex than the one here proposed since all Stewart's knives cut on a common

cutting circle. Another solution is addition of flaking knives to the face of an end-mill headrig chipper. Such designs have been described by Reuter (1972) and are in use by several companies including Gebrüder Linck and—in somewhat different configuration—Soderhamn Machine Works. It can be argued, however, that none of these simpler cutterheads make a flake of optimum quality for structural particleboard, although they may yield reasonably good flakes and a reasonably smooth board face or edge if knives are properly maintained.

Alternatively, torn grain from chipping heads could be smoothed in the planing mill by planers specially designed to yield valuable engineered flakes for structural particleboard (Heebink 1975). This solution is difficult to implement, however, because most mills have substantial investments in conventional planers, most of which would have to be discarded in favor of flake-making planers of new design.

Admittedly, design of the proposed cutterhead will be difficult as will the job of resharpener knives along a helix and securing each knife so that it cuts on a precisely specified cutting-circle different from that of every other knife in the head. However, the effort

seems worthwhile since improvement of surface quality is one of the two most pressing challenges facing the designers of such machines. Log guidance, to be discussed in a later paper, is the second major problem.

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